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ENGINEERING AND SCIENTIFIC RESEARCH AT WES

Miscellaneous Paper O-73-1

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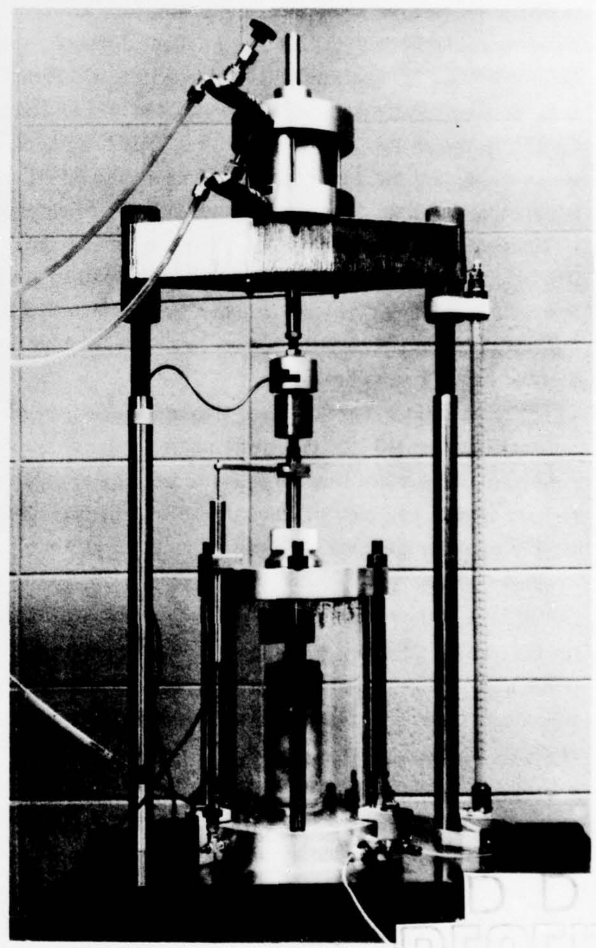
EARTHQUAKE ENGINEERING AT WES,

by L. W. Heller, Soils and Pavements Laboratory

The historic role of the U. S. Army Corps of Engineers in flood control and river navigation has led to the construction of dams, levees, and locks along the paths of continental rivers. Rivers, of course, often follow fault-induced depressions on the earth's crust, and faulting is a known source of earthquakes. Earthquake damage to dams, levees, locks, and associated appurtenances is, therefore, a potential hazard for these Corps of Engineers facilities. The capabilities for earthquake analysis that are currently being developed and the desire to minimize potential damage to Corps dams have led the Office, Chief of Engineers (OCE), to assign various earthquake engineering studies to the Waterways Experiment Station.

In an effort to improve current Corps of Engineers design procedures, one of the tasks assigned to the WES includes a review of the latest methods of designing earth and rock-fill dams to withstand the destructive effects of earthquakes. The task consists of a continuing assessment of the state of the rapidly developing art of earthquake engineering as applied to soil, rock, and earth-rock mixtures, and to the behavior, stability, and safety of structures composed of these materials under earthquake loading. Directed work activities are: (a) in-depth state-of-the-art studies, including lectures and symposia, (b) consultation with noted authorities, (c) development of laboratory test procedures, (d) development of field test procedures, (e) checking and exercising computer analysis methods, and (f) compiling instructions, memoranda, and reports, as appropriate, for District, Division, and OCE use.

Since 1969, the WES has been developing laboratory test methods which subject samples of soil to earthquake-like cyclic stresses in order to assess the expected strength characteristics of soils during earthquakes. Cyclic-loading triaxial test devices have been obtained for this purpose; the triaxial chamber, test specimen, and cyclic loading frame are shown in fig. 1. With this device, liquefiable soil materials have been identified on several Corps projects.



SIMULATION OF NUCLEAR FALLOUT USING A NEUTRON-ACTIVABLE TRACER, *by E. J. Leahy, Explosive Excavation Research Laboratory*

Project DIAMOND ORE, jointly funded by the Defense Nuclear Agency and the Office, Chief of Engineers, is a series of experiments employing computer-designed high-explosive charges to simulate nuclear-explosive cratering detonations. The experiments seek to answer the question, "How does the type and amount of stemming in the emplacement hole of a nuclear device influence the size of the resulting crater, the fraction of radioactivity vented into the atmosphere, and the radioactive fallout pattern?" Both the military engineer and the civil engineer need the answer if they are to employ nuclear explosives on the battlefield or in civil/military construction projects. The WES Explosive Excavation Research Laboratory (EERL), located in Livermore, California; the Lawrence Livermore Laboratory (LLL), at the same location; the Stanford Research Institute (SRI), Menlo Park, California; and Science Systems and Software (S^3), La Jolla, California, are all involved in the project. EERL, LLL, and S^3 are designing the high-explosive charges, and EERL is conducting the field tests. EERL and SRI are developing a simulant for nuclear fallout. The technique being developed may also be usable for long-term tracing of sand and silt movement in an aquatic environment. The following paragraphs describe the success achieved thus far in developing a suitable simulant.

The technique developed to determine fraction of radioactivity vented to the atmosphere and to model radioactive fallout involves the surface adsorbing of iridium (Ir) on quartz particles of known size and density. The tagged particles are then uniformly mixed throughout an explosive charge prior to placement of the charge in a drilled hole at the proper depth. Aluminum trays are placed on the surface of the ground surrounding the detonation point and in the predicted downwind fallout pattern area to collect the debris ejected by the explosion. The postshot contents of each tray are recovered, weighed, and sieved into five particle size ranges. A sample of each particle size is encapsulated and neutron-activated. Gamma-ray spectra emitted from the irradiated samples are measured in a gamma-ray spectrometer, and the iridium contents are determined from the amplitudes of the 0.316-Mev gamma-ray peaks. Total iridium content of each collector tray is calculated and isodeposition lines of the fallout pattern are plotted. Integration of this pattern to determine the amount of iridium deposited determines the fraction of the total iridium that is vented by the explosion. The iridium mass deposition curves are converted to gamma-ray dose rate curves by relating the iridium deposition in grams per square meter to roentgens per hour at one hour after the explosion.

Sample analysis techniques developed during the project permit the amount of iridium contained in a debris (soil falling from the dust cloud) sample to be determined directly from the gamma-ray spectra of a debris sample without performing chemical separations of the iridium from the sample. Fig. 1 shows the gamma-ray spectrum of 1 gram of a typical soil sample when neutron-activated (curve 2). Curve 3 is the spectrum of 1×10^{-7} grams of iridium. Curve 1 is the spectrum of 1 gram of soil containing 1×10^{-7} grams of iridium. The amount of iridium in a sample is determined by subtracting the area of the 0.316-Mev peak of a sample known to be free of iridium from the 0.316-Mev peak area of a collected sample. A relationship developed between the areas of the scandium-46 peak at 0.89 Mev (scandium is an element contained in all soils) and the iridium 0.316-Mev peak permits determination of the 0.316-Mev peak area in an iridium-free soil sample at any time after neutron-activation.

The amount of iridium employed to tag the particles (0.001 gram per gram of particles) permits one to find 25 tagged particles in a gram of soil (approximately 2×10^5 particles per gram of soil). This is a sensitivity of about one part in 10,000.

Four cratering detonations using one-ton aluminized ammonium nitrate charges were accomplished at Trinidad, Colorado, to field test the fallout simulation technique. Fig. 2 shows the fallout pattern from two of the events, M-13 and M-16, each stemmed in a different manner. Test results show that the iridium tracer does simulate nuclear fallout and allows the effectiveness of various types of stemming to be compared. Multiplying the mass of iridium deposited per square meter by 5×10^4 converts the iridium deposition to roentgens per hour at one hour after burst time.

Additional testing of the fallout simulant was conducted at Fort Peck, Montana, in October-November 1972 and is scheduled for Fort Polk, Louisiana, in June-July 1973.

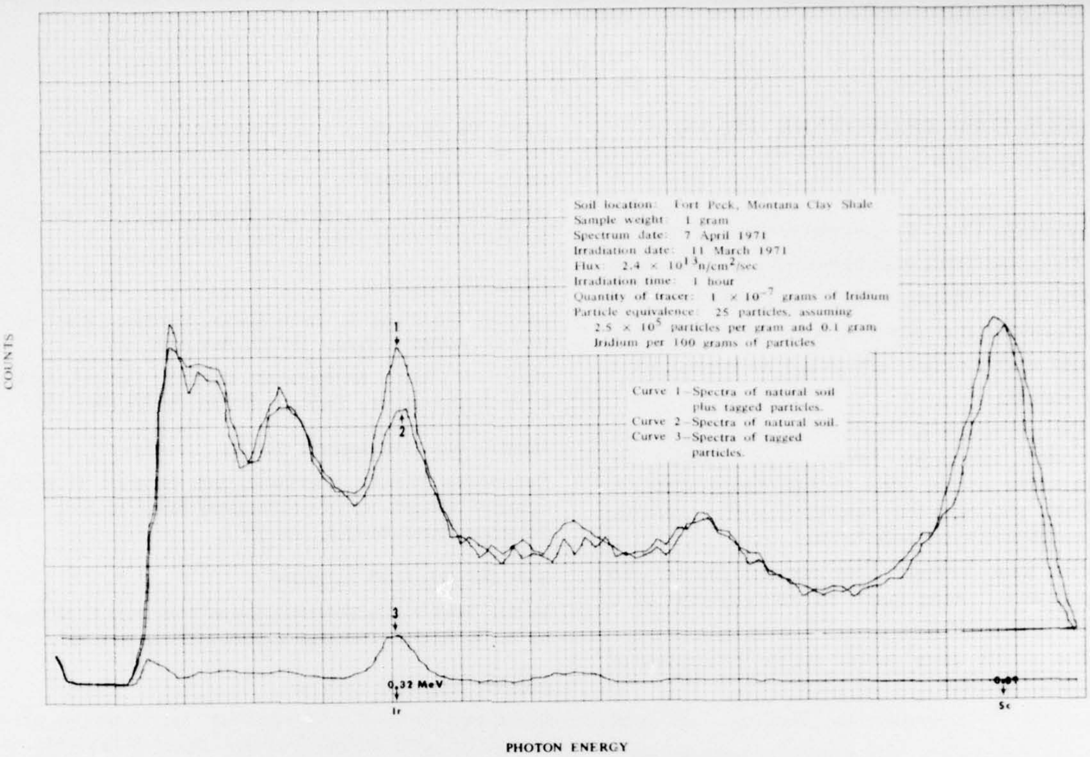


Fig. 1. Sample gamma spectra for three irradiated samples; total number of gamma rays detected at a given energy is plotted against that energy in millions of electron volts (Mev)

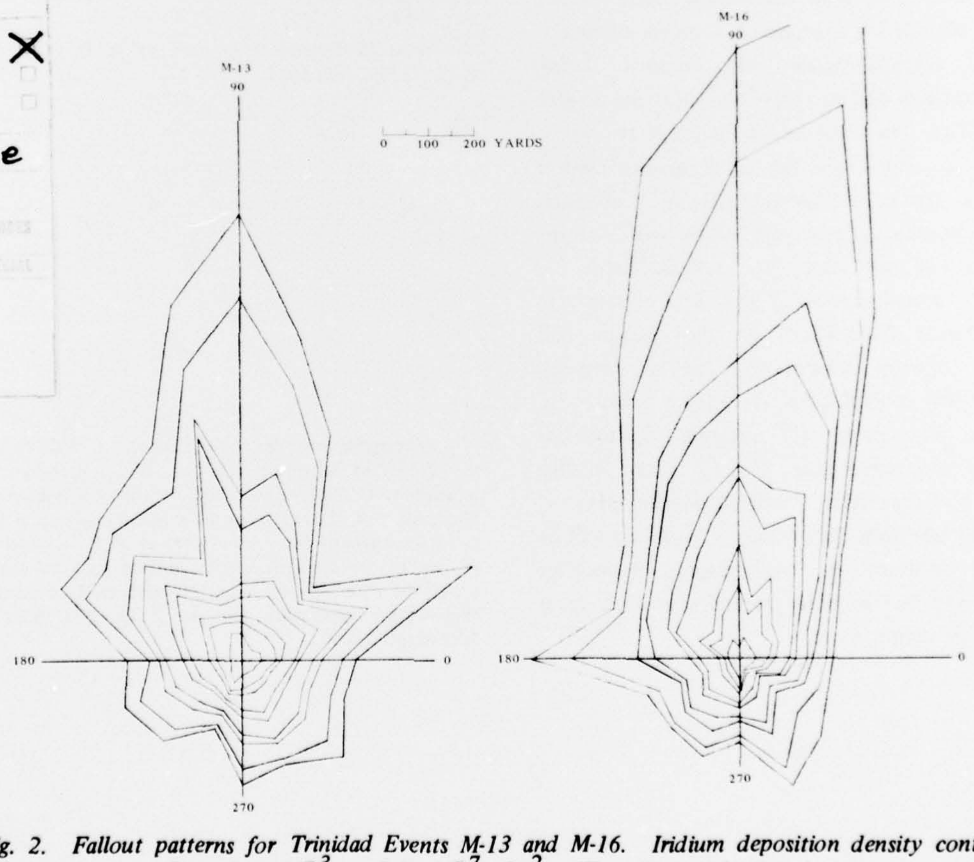


Fig. 2. Fallout patterns for Trinidad Events M-13 and M-16. Iridium deposition density contours from 5 × 10^{-3} to 5 × 10^{-7} g/m^2. (For all particle sizes.)

BELTZVILLE DAM PROTOTYPE TESTS,

by E. D. Hart, Hydraulics Laboratory

The Beltzville Dam, a multiple-purpose project, is located on Pohocopo Creek in the Lehigh River Basin about 80 miles northwest of Philadelphia, Pa. Hydraulic field tests will be conducted at the project in April 1973. Prototype measurements at this project are of special interest for a number of reasons.

a. The prototype is very similar in design to the model, the latter having been utilized for extensive testing prior to final design approval. This presents the opportunity for realistic model-prototype correlation.

b. The long, straight dam conduit (about 178 diameters) lends itself to development of a uniform gradient.

c. The unique water quality design features are of special interest.

A slug-type flow known as "burping" has been experienced at the project. This condition presents surge problems in the stilling basin. In order to study this phenomenon, fluctuating pressures in the conduit will be measured and correlated with the stilling basin action, which will be recorded by means of a movie camera.

Embedded instrumentation was installed during construction to ensure testing capabilities after the project reservoir was filled. Tests will be conducted in two areas, the 7-ft-diameter conduit and the water quality control intake structure. The more important data to be obtained will include (a) hydrostatic pressures determined by means of seven piezometer pairs along the conduit length, (b) conduit velocity measurements by means of a traversing probe, (c) pressure fluctuations on the conduit wall measured by pressure transducers, (d) air demand downstream of the control gates, (e) impact pressures in the water intake tower, (f) pressure fluctuations downstream of a control gate, and (g) water quality measurements of temperature, dissolved oxygen, pH, and conductance. Signals from the pressure transducers will be amplified and recorded on oscillographs. Piezometer measurements will be recorded manually as read from pressure gages or manometers.

REPORTS RECENTLY PUBLISHED BY WES

Concrete Laboratory:

Resin Concretes: A Literature Review, by J. E. Dennard, Jr., Miscellaneous Paper C-72-21, Sep 1972.

Hydraulics Laboratory:

Shoaling Conditions, St. Louis Harbor, Mississippi River, by J. J. Franco, Technical Report H-72-7, Nov 1972.

Navigation Channel Improvement, Gastineau Channel, Alaska, by F. A. Herrmann, Jr., Technical Report H-72-9, Nov 1972.

Mobility and Environmental Systems Laboratory:

Determining Presence, Thickness, and Electrical Properties of Stratified Media Using Swept-Frequency Radar, by J. R. Lundien, Technical Report M-72-4, Nov 1972.

Soils and Pavements Laboratory:

In Situ Tests for the Determination of Rock Mass Shear Strength, by T. W. Zeigler, Technical Report S-72-12, Nov 1972.

Weapons Effects Laboratory:

Design and Testing of a Blast-Resistant Reinforced Concrete Slab System, by M. E. Criswell, Technical Report N-72-10, Nov 1972.

Explosive Excavation Research Laboratory:

Explosive Excavation for Water Environment and Road Cut Applications, by R. L. LaFrenz, Miscellaneous Paper E-72-1, Jun 1972.

Craters as Engineering Structures, by W. C. Day, Miscellaneous Paper E-72-2, Jul 1972.

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